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Learning effect of the six-minute walk test in healthy young persons

Efekt uczenia się testu marszowego 6-minutowego u zdrowych młodych osób

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Keywords
six-minute walk test, learning effect, training effect, practice effect

Abstract
Introduction: The six-minute walk test is a standardised and frequently used measure of tolerance for exercise. It is usually applied to patients with disorders of the respiratory and circulatory systems. Researchers differ in their opinion about whether what is referred to as the *learning effect* exists, and consequently, whether a preliminary test should be conducted prior to the actual test.
Aim: The aim of this study was to determine whether a learning effect occurs in the six-minute walk test, by conducting the test twice with healthy young persons for whom the test should not constitute an excessive strain. The obtained results will be used for further research aimed at assessing the learning effect in patients with interstitial lung diseases.
Material and Methods: The study participants comprised 30 students of physiotherapy at the University of Physical Education in Krakow (22 women and 8 men) aged between 20 to 26 years (with a mean age of 23.2 ± 1.56 years). The participants underwent two trials of the six-minute walk test at an interval of at least 15 minutes (i.e., after the following parameters had returned to their resting values: exhaustion, shortness of breath, heart rate, and blood pressure). Both trials of the test were conducted in the same conditions. None of the study participants were informed about the aim of the experiment.
Results: The mean of the six-minute walk distance among all study participants was 748.13 ± 56.81 m in the first trial and 773.88 ± 70.32 m in the second trial. Thus, a statistically significant difference was found in the walk distance of the first and the second trial. Most participants (90%) improved their distance in the second trial. a statistical analysis showed that the difference in the obtained distance between Trial 1 and Trial 2 was statistically significant among all participants and for both men and women ($p<0.05$), even though as much as 80% of the participants declared after the first trial that they would be unable to walk faster. The mean differences between Trials 1 and 2 for the entire sample amounted to 25.75 ± 34.85 m.
Conclusions: The results indicate the existence of the learning effect in the six-minute walk test among young healthy persons. Consequently, a preliminary test should be conducted with the study participants prior to the main test, as a routine procedure to prevent an incorrect interpretation of the results. The analysis should be based on the results obtained in the second test. This will guarantee the elimination of the learning effect and the correct interpretation of the potential improvement in the achieved distance as an effect of physical training or a therapeutic procedure. Further research should involve testing for the existence of the learning effect in persons with a decreased tolerance for exercise and/or with different chronic disorders of the respiratory system.

Słowa kluczowe
test 6-minutowego marszu, efekt uczenia, efekt treningu, efekt praktyki

The individual division on this paper was as follows: a – research work project; B – data collection; C – statistical analysis; D – data interpretation; E – manuscript compilation; F – publication search

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Streszczenie

Wprowadzenie: 6-minutowy test marszowy jest ustandaryzowanym i często stosowanym miernikiem tolerancji wysiłku. Stosuje się go zazwyczaj u chorych ze schorzeniami układu oddechowego oraz układu krążenia. Istnieją różnice poglądów na temat istnienia tzw. efektu uczenia się, a co za tym idzie konieczności wykonywania testu próbnego przed wykonaniem właściwej próby.

Cel: Celem pracy było sprawdzenie, czy występuje efekt uczenia w dwukrotnie przeprowadzonym teście 6-minutowego marszu u młodych, zdrowych osób, dla których test 6-minutowego marszu nie powinien być zbyt dużym obciążeniem. Otrzymane wyniki wykorzystane będą w kolejnych badaniach, mających na celu ocenę efektu uczenia u chorych z chorobami śródmiąższowymi płuc.

Metody: Badaniami objęto 30 studentów kierunku Fizjoterapia Akademii Wychowania Fizycznego w Krakowie (22 kobiety i 8 mężczyzn) w wieku od 20 do 26 lat (średnia 23,2 ± 1,56 lat). Badanie polegało na przeprowadzeniu dwóch prób testu 6-minutowego marszu w co najmniej 15-minutowym odstępie (po powrocie do wartości spoczynkowych parametrów: zmęczenia, duszności, tętna i ciśnienia krwi tętniczej). Warunki przeprowadzania obu prób były identyczne. Żadnej spośród badanych osób nie udzielono informacji na temat celu przeprowadzanego doświadczenia.

Wyniki: Średni dystans marszu 6-minutowego w całej grupie wyniósł: w pierwszej próbie 748,13 ± 56,81, w drugiej 773,88 ± 70,32. Wykazano istotną statystycznie różnicę w dystansie marszu 6-minutowego zarówno w pierwszym, jak i w drugim teście marszowym. Większość badanych osób (90%) poprawiło swój dystans w drugiej próbie marszowej. Analiza statystyczna wykazała, że różnica w uzyskanych dystansach próby 1 i 2 jest istotna statystycznie zarówno w całej grupie, jak i w grupach kobiet i mężczyzn ($p < 0,05$), pomimo że aż 80% badanych stwierdziło po 1 próbie, że nie było w stanie iść szybciej. Średnia różnica między rezultatem 1 i 2 próby dla całej grupy wynosiła 25,75 ± 34,85 m.

Wnioski: Wyniki niniejszego badania wskazują na istnienie w grupie młodych, zdrowych osób efektu uczenia w przypadku testu marszu 6-minutowego. W związku z tym, w celu uniknięcia niewłaściwej interpretacji wyników testu, konieczne jest w tej grupie osób wykonywanie próby wstępnej przed testem właściwym jako rutynowej procedury. Do analizy powinno się brać pod uwagę wyniki drugiej próby. Zagwarantuje to wyeliminowanie efektu uczenia i właściwe zinterpretowanie ewentualnej poprawy dystansu jako efektu treningu fizycznego/procedury terapeutycznej. W dalszej kolejności konieczne jest także sprawdzenie istnienia efektu uczenia u osób z obniżoną tolerancją wysiłku i/lub z różnymi przewlekłymi schorzeniami układu oddechowego.

INTRODUCTION

The six-minute walk test (6MWT) is also called the "corridor walk test" due to the fact that it is usually performed in a hospital corridor. It is a diagnostic method used to measure the patient's tolerance for exercise, evaluate various medical procedures (medication, rehabilitation programmes, and training programmes), determining the patient's qualification for adequate treatment (including rehabilitation or surgical procedures), assess exertional desaturation, and evaluate the effects of rehabilitation[1-3]. Due to the fact that the speed of walking is controlled by the test participants, the 6MWT allows for a submaximal assessment of their physical capacity[4].

The 6MWT dates back to the early 1960s[1,4-7], and is a modified version of the twelve-minute walk test proposed by McGavin in 1976[8], which in turn was a modification of the twelve--minute run test by Cooper[6]. The six--minute test demonstrates a very good correlation with the twelve-minute test, while at the same time allowing for a reduction in the test participant's level of exhaustion by shortening the duration of the test[1,3,9]. Thanks to this, the 6MWT has come to be widely applied in clinical trials[10].

The six-minute walk test is well tolerated by patients and does not require specialist equipment, which minimises the testing costs. The test is safe because it is the patient who decides how quickly he or she walks, and whether he or she needs to take a break or to completely abort the test. In addition, no special training of the personnel performing the test is required[1,4].

Diagnostic value of the six-minute walk test

The 6MWT is an easy method of assessing the tolerance for exercise in the test participants, their adaptation to everyday activities, as well as the effects of therapy and their prognosis. The test is essentially a method of assessing the test participant's adaptation to everyday physical efforts[4]. Therefore, it can also be used in healthy people of various ages to evaluate their physical capacity[2].

The 6MWT can be used both with hospitalised patients and with outpatients. It should be applied as an additional test in evaluating tolerance for exercise, prognoses, effects of a rehabilitation programme, and adaptation to everyday activities. The results that can be obtained by conducting the six-minute walk test show very well the patients' changes in tolerance for exercise. However, this test does not allow for an assessment of the specific causes of the observed changes[4], as it only allows for an evaluation of the general reaction to physical exercise of all systems in the human body, but does not provide information on the functioning of particular organs[1,3].

Factors affecting variability in the 6MWT results

Despite the existence of guidelines for the performance of the six-minute walk test, there are still many factors that can cause variability in its results. These factors are both dependent on and independent of the persons performing the test (including both the test participants and the examiners). The factors dependent on the persons performing the test, which can significantly affect the result, should be minimised (or excluded) to the maximum possible extent. Conducting the test in accordance with the accepted standards should help in achieving this[1,3].

Causes of result variability independent of the testing method

The results obtained in the six-minute walk test will also differ depending on many factors that are independent of the persons performing the test. These factors should therefore be taken into account when interpreting the results. In accordance with the guidelines of the American Thoracic Society of 2002 (ATS Statement: Guidelines for

the Six-Minute Walk Test) the causes of variability in the results that are independent of the method of conducting the 6MWT include[1]:

- Factors that will shorten the distance of the 6MWT:
  - lower body height,
  - higher body weight,
  - older age,
  - female sex,
  - cognitive disorders,
  - musculoskeletal disorders,
  - lung diseases (asthma, COPD, cystic fibrosis, interstitial lung disease) (in various study groups, a specific walk distance can have prognostic significance),
  - cardiovascular diseases (i.e., stroke, CAD).
- Factors that will increase the distance of the 6MWT:
  - higher body height (with longer lower limbs),
  - male sex,
  - medication prior to the test,
  - use of oxygen therapy in patients with exertional hypoxaemia.

Causes of result variability related to the testing procedure

Contrary to the factors that are independent of the test participants and examiners, other factors that depend on the testing method (related to the testing procedure) should be eliminated to the maximum possible extent. The causes of variability in the results that are related to the testing procedure include[1]:

- The length of the corridor:

A shorter corridor forces test participants to perform more reversals (changes in the direction) of walking, which results in a shortening of the walk distance in the 6MWT, and makes the comparison of the results with a previously performed walk test impossible. It has been proven that the minimum length of the corridor (one direction) needed for the test to be independent of the number of reversals is 30 m[1].

- The impact of encouraging instructions:

It is assumed that the use of instructions encouraging the patient to walk faster significantly affects the increase in the walk distance in the 6MWT. Therefore, it is recommended that persons conducting the test avoid encouraging the participant during the test, i.e. using other additional words of encouragement, as well as nonverbal communications that could encourage the participant to walk faster[1,3]. Only standard communication should be used to encourage the patient[1,3]. The participant can only be informed about the time remaining until the end of the test (every minute); and otherwise it is forbidden to talk with the participant during the test, as this could also affect the result. In many patients with advanced lung disease, conversation may also constitute an additional factor that will increase their exhaustion. Furthermore, conversation with the participant and/or conversation between the examiners may cause distractions and overlooking (failure to mark) the participant's passing the length of the corridor (one lap).

- The speed of walking:

Another factor that can affect the walk distance is the instructions given to the test participant at the beginning of the test, i.e. whether he or she is told to walk "as fast as possible" (step as fast as possible)[11], or walk "the longest distance possible"[1,3]. Currently, the use of the second version of the instruction is recommended. The instruction to walk as fast as possible allows the patient to achieve a longer walk distance during the six-minute test; however, it often results in an excessive increase in the speed at the beginning of the walk and quicker exhaustion, as well as an excessive stress on the cardiovascular system in some patients with heart disease[1].

- The patient's motivation while performing the test:

A high level of motivation can have a significant impact on the increase in the walk distance in the 6MWT. The patient's motivation during the 6MWT may depend on many individual factors including, among other things: the patient's mental state, temporary bad/good moods, unpleasant/pleasant experiences in the recent past, or a positive/negative attitude towards the disease and treatment. All this will have a significant impact on the length of the walk distance in the six-minute test.

- The patient's shoes and clothes:

Appropriate clothes and shoes can result in changes in the test result. Conversely, uncomfortable shoes which are not suitable for fast walking (e.g. slides, slippers) will often cause deceleration, discomfort during walking, exhaustion and pain in the lower limbs (often in the tibialis anterior muscles, as a result of the continuous effort to keep the slippers on the feet) during and/or after the test. Unfortunately, during the patients' stay in the hospital, they are often forced to walk in inappropriate footwear due to the lack of other, more comfortable, options.

- The use of glasses in a situation where the patient uses them for walking:

The lack of glasses may be the first cause of imbalances, uncertain walking and deceleration.

- The use of walking aids (walkers, canes, oxygen):

The use of aids during the test can significantly improve the results, particularly in patients with more advanced lung disease (with a reduced tolerance for exercise). Therefore, it should be considered whether the use of such an aid results from the occurrence of the chronic disease or defect of the musculoskeletal system, or whether it is only a temporary aid. In the latter case, postponing the test until the injury or disease has been cured would be a better solution. In the case of a permanent disability which requires the constant use of aids, it will be necessary to make a note regarding the orthopaedic aid used during the test.

- The number of preliminary tests:

The number of preliminary trials is the reason most often mentioned fir variability in the results, especially in a situation where the patient is told to walk the longest distance possible, rather than to walk the distance as quickly as possible (i.e. at the fastest speed possible, in accordance with the instruction: "Walk as fast as possible").

Learning effect – preliminary testing

In many diagnostic tests, it is necessary to take into account the so-called

"learning effect", also known as the training effect or the practice effect. This effect also applies to the six-minute walk test. After the completion of the test, many patients state that they would be able to walk much faster and/or walk farther. When asked about the cause of their slower walk, they reply that they did not think that it was necessary to walk faster, or that they did not think that they would be able to walk as fast. Therefore, it seems logical that a preliminary test should be conducted prior to the actual test in order to check whether the results of the second trial are not significantly higher than the results of the first trial. This may include a test conducted on the same day after an adequate break, which will allow the patient to rest, or a test conducted on the following day. Checking after how many preliminary trials the six-minute walk test reaches a constant level may also be a reasonable approach. So far, many authors have reached the conclusion that the test reaches its constant level after two trials in the same week[1,7,12]; although, according to the guidelines of the ATS of 2002, the result of the 6MWT is only slightly higher in the case of a test carried out on the following day, and according to particular publications the mean increase in the value ranges from 0% to 17%[1,13-18]. The training effect may be related to a better coordination of movements, finding the optimal length of steps, and overcoming fear[1].

AIM OF THE STUDY AND RESEARCH QUESTIONS

The aim of the study was to determine whether a learning effect would occur in two trials of the six-minute walk test in healthy young people.

Research questions:

1. Are there differences in the distances obtained in two trials of the six-minute walk test by healthy young people?
2. Is the distance obtained by the participants longer in the second trial?
3. Should the assessment of tolerance for exercise take into account the result of the first or of the second trial?
4. Are there differences in the feelings of exhaustion measured before and after the 6MWT trials?
5. Is the exhaustion felt by the participants after the second 6MWT trial greater than the feeling of exhaustion after the first trial?
6. Is a potential improvement in the distance in the second walk test reflected in the responses given after both tests to the following questions: Would you be able to walk farther? Would you be able to walk faster?

MATERIAL AND METHODS

The study was conducted with students enrolled in the Faculty of Motor Rehabilitation at the University of Physical Education in Krakow. The study involved 30 persons, including 22 women and 8 men, aged between 20 to 26 years (with a mean age of 23.2 ± 1.56 years) ($p > 0.05$).

Testing conditions

The test was conducted in a corridor located in the building of the Department of Motor Rehabilitation at the University of Physical Education in Krakow. The test location was a 40-metre corridor, which is rarely visited, where a 30-metre path was marked out. The start of the path was marked with a bright line and the reversal places were marked with orange traffic cones painted with white reflective stripes. The test was conducted in accordance with the guidelines of the American Thoracic Society of 2002[1], which also were recommended by the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) in 2011[3].

Testing procedure

The study involved two trials of the six-minute walk test.

Each participant was first informed about the testing methodology. The method for walking the path was presented to them, and each participant was informed about the necessity of walking the test without running. The study participants did not know the aim of the study, which was an attempt to determine the existence of a learning effect in the 6MWT, and each participant gave their informed consent to participate in the study.

In addition, before and after each trial, the level of general exhaustion of the study participants was determined using the Borg Scale for perceived exertion (0-10 points).

Test 1

After a ten-minute rest during which they learned the necessary information, each person stood on the starting line, where he or she received the instruction to walk "as long a distance as possible during the six minutes of the test". Each minute during the test, the participants were informed about the time remaining to the end of the test. No additional instructions were used that could encourage the participants to walk faster.

After the first trial was completed, the participants were asked two questions. The first question was asked in accordance with the guidelines of the ATS of 2002[1]; whereas the second one, which concerned their speed of walking, was added in this study:

1. Would you be able to walk farther?
2. Would you be able to walk faster?

The participants were also asked about the reason for a possible inability to walk farther and/or faster.

Test 2

Each participant rested for approximately 15 minutes, until their symptoms of exhaustion had completely disappeared and the measured parameters had returned to the pre-test values (resting values). When the test participant was ready for the second trial, he or she stood on the starting line, where an identical instruction was given as in Trial 1, i.e. "walk as long a distance as possible during the six minutes of the test". As in the first trial, the participants were informed each minute about the time remaining to the end of the test, and no additional instructions were used to encourage the participants to walk faster.

After Test 2, the test participants were asked the same questions as in Test 1.

Statistical Methods

A statistical analysis of the basic parameters of all the collected measurements was carried out. The distribution of the quantitative variables is presented in the tables below, including the arithmetic mean (x), standard deviation (SD), and the minimum and maximum values. All of the calculations were performed using STATISTICA software. For all of the statistical calculations, the level of significance was set at $p = 0.05$. To check whether a learning effect may have occurred in the participant while performing the six-minute walk test, the distances obtained in the two trials were compared using Student's *t*-test, and Pearson's *r* correlation was used to examine the relationship between the quantitative variables. The results of the analysis of the qualitative variables are expressed as a percentage.

RESULTS

No statistically significant differences were found between the groups of women and men in relation to their age and BMI values (Table 1).

However, the mean length of the distance walked by men was longer than the mean length of the distance walked by women, both in the first and second trials (Table 2). Concerning the feelings of exhaustion, the group of men demonstrated a significantly higher exhaustion level after the first trial than the women's group ($p = 0.05$) (Table 2).

The six-minute walk test was completed by all of the participants, and an increase in the walk distance in the second trial was observed in the majority of the test participants (90%) (Table 3). Twenty-seven persons (90%) improved their distance result in the second trial; whereas only three persons who completed the second trial obtained a shorter distance. Also, the increase in the distance walked in the second trial was much higher in the group of men (800.25 ± 55.81 m vs. 842.75 ± 65.46 m, with $p = 0.0001$) than in the group of women (729.18 ± 42.12 m vs. 748.84 ± 54.18 m, with $p = 0.01$) (Tables 3 and 4), which may result in a greater exhaustion level in healthy young people. In the first trial, the men reported significantly greater feelings of exhaustion than the women, while obtaining a longer distance in the 6MWT ($p = 0.05$) (Table 2). After the second trial of the 6MWT, no significant difference was found in the feelings of exhaustion between the groups of men and women, even though the men obtained a significantly longer walk distance. Furthermore, in the comparison of the feelings of exhaustion assessed in par-

Table 1

Overview of the study participants according to sex

Variables	Total n = 30			Women n = 22			Men n = 8			Statistical significance *p* between the groups of men and women
	$\bar{x} \pm SD$	min	max	$\bar{x} \pm SD$	min	max	$\bar{x} \pm SD$	min	max	
Age [years]	23.2 ± 1.56	20	26	23.05 ± 1.46	20	25	23.63 ± 1.85	20	26	0.37
Height [m]	171.37 ± 6.12	161	182	169.55 ± 5.32	161	179	176.38 ± 5.55	168	182	0.05
Body weight [kg]	63.5 ± 9.26	49	95	61.36 ± 9.36	49	95	69.38 ± 6.23	60	78	0.05
BMI [kg/m^2]	21.6 ± 2.9	18.1	32.1	21.3 ± 2.9	18.2	32.1	22.4 ± 2.7	18.1	25.9	0.358

Table 2

Mean distance, standard deviation, and minimum and maximum values of the feeling of exhaustion and the distances achieved in the first and second trial among all participants, and among women and men

Variables	Total			Women			Men			Statistical significance *p* between the groups of men and women
	$\bar{x} \pm SD$	min	max	$\bar{x} \pm SD$	min	max	$\bar{x} \pm SD$	min	max	
Distance in the 6MWT Trial 1 [m]	748.13 ± 56.81	628	870	729.18 ± 42.12	628	809	800.25 ± 55.81	686	870	**0.001**
Exhaustion* before the 6MWT Trial 1 [pt]	0.02 ± 0.09	0	0.5	0.02 ± 0.1	0	0.5	0.00 ± 0.00	0	0	-
Exhaustion after the 6MWT Trial 1 [pt]	1.55 ± 1.21	0	5	1.25 ± 1.17	0,0	5,0	2.38 ± 0.92	1.0	4.0	**0.05**
Distance in the 6MWT Trial 2 [m]	773.88 ± 70.32	584	925	748.84 ± 54.18	584	826	842.75 ± 65.48	715	925	**0.001**
Exhaustion* before the 6MWT Trial 2 [pt]	0.03 ± 0.13	0	0.5	0.05 ± 0.15	0	0.5	0.00 ± 0.00	0	0	-
Exhaustion after the 6MWT Trial 2 [pt]	1.95 ± 1.25	0	5	1.70 ± 1.29	0	5	2.63 ± 0.92	1	4	0.072

Abbreviations: 6MWT – six minute walk test; x – arithmetic mean; SD – standard deviation; p – probability level; min – minimum; max – maximum;
* – feelings of exhaustion were assessed using the Borg Scale (0-10)

ticular groups (total, men, women), no significant increase in the exhaustion level was observed in the group of men following the first and the second trials (Table 5).

The difference between the mean distance obtained in the second trial and the mean distance obtained in the first trial amounted to 25.75 ± 34.85 m. The differences of the distances ranged from -70 to 104 m (Table 4).

After both the first and second trials of the six-minute walk test, almost all the participants (except for one person, a woman in Trial 2) stated that they would be able to walk farther after the completion of the test (the response to the question: "Would you be able to walk farther?") (Table 6).

When asked "Would you be able to walk faster during the test?" after the completion of the first trial, 24 persons (80%) replied that they would not be able to walk faster. a similar distribution was observed in the responses of the groups of men and women (77.3% of the women and 87.5% of the men replied that they would not be able to walk faster than in Trial 1) (Table 7). After the completion of the second trial, all of the respondents answered this question in the negative (Table 7).

DISCUSION

The six-minute walk test is used to measure tolerance for exercise, primarily in patients with cardiovascular or lung diseases. It allows, among other things, for an evaluation of the results of the implemented therapy and an assessment of the prognosis in these patients, and provides an opportunity to do this in a very cheap way, which is available to everybody. It also can provide an objective evaluation of the physical capacity in healthy people. Its popularity results from several factors: (1) the ease of testing; (2) low equipment requirements; (3) no need for specialised equipment; (4) it is a type of applied effort which corresponds to many activities of everyday life; (5) the adequate sensitivity of the test allows for documenting improvements after pulmonary rehabilitation or physical training; and (6) there are set levels of clinically significant differences (minimum differences that indicate evidence of an improvement or worsening, at approx. 54 m)[1,19].

Table 3

Mean distance in Trials 1 and 2 of the 6MWT, and the statistical significance between women and men, and among all study participants

Variable	Distance in the 6MWT Trial 1 [m]	Distance in the 6MWT Trial 2 [m]	Statistical significance *p*
	$\bar{x}$ ± *SD*	$\bar{x}$ ± *SD*	
Total	748.13 ± 56.81	773.88 ± 70.32	**0.001**
Women	729.18 ± 42.12	748.84 ± 54.18	**0.01**
Men	800.25 ± 55.81	842.75 ± 65.46	**0.0001**

Abbreviations: 6MWT – six minute walk test; x – arithmetic mean; SD – standard deviation; p – probability level; min – minimum; max – maximum

Table 4

The mean, standard deviation, and maximum and minimum values of the differences in distances achieved in the 6MWT among women and men, and among all study participants

Variable	Differences in the distances obtained in both 6MWT trials [m]		
	$\bar{x}$ ± *SD*	Min	max
Total	25.75 ± 34.85	-70 m	104 m
Women	19.65 ± 37.92	-70 m	104 m
Men	42.5 ± 16.8	15 m	68 m

Abbreviations: 6MWT – six minute walk test; x – arithmetic mean; SD – standard deviation; p – probability level; min – minimum; max – maximum

Table 5

Comparison of the exhaustion results following Trials 1 and 2 of the 6MWT among women and men, and among all study participants

Variable	Exhaustion after the 6MWT Trial 1 [m] $\bar{x}$ ± *SD*	Exhaustion after the 6MWT Trial 2 [m] $\bar{x}$ ± *SD*	Statistical significance *p*
Total	1.55 ± 1.21	1.95 ± 1.25	**0.006**
Women	1.25 ± 1.17	1.70 ± 1.29	**0.008**
Men	2.38 ± 0.92	2.63 ± 0.92	0.225

Abbreviations: 6MWT – six minute walk test; x – arithmetic mean; SD – standard deviation; p – probability level; * – the exhaustion level was assessed using the Modified Borg Scale

Table 6

Distribution of the answers to the question: "Would you be able to walk farther?", following both trials of the 6MWT

Question	6MWT trial	Response Yes/No	Total n (%)	Men n (%)	Women n (%)
"Would you be able to walk farther?"	**6MWT Trial 1**	**Yes**	30 (100)	8 (100)	22 (100)
		No	0 (0)	0 (0)	0 (0)
	6MWT Trial 2	**Yes**	29 (96.66)	8 (100)	21 (95.45)
		No	1 (3.33)	0 (0)	1 (4.55)

Abbreviations: 6MWT – six-minute walk test; *n* (%) – number of Yes or No responses (percentage of Yes or No responses)

Table 7

Distribution of the answers to the question: "Would you be able to walk faster?", following both trials of the 6MWT

Question	6MWT trial	Response Yes/No	Total n (%)	Men n (%)	Women n (%)
"Would you be able to walk faster?"	**6MWT Trial 1**	**Yes**	6 (20)	1 (12.5)	5 (22.7)
		No	24 (80)	7 (87.5)	17 (77.3)
	6MWT Trial 2	**Yes**	0 (0)	0 (0)	0 (0)
		No	30 (100)	8 (100)	22 (100)

Abbreviations: 6MWT – six minute walk test; *n* (%) – number of Yes or No responses (percentage of Yes or No responses)

The aim of this study was to determine whether a learning effect would occur in the six-minute walk test, when conducted twice with healthy young persons. As both trials were performed by a given person on the same day, following a short interval, an improvement in the participants' physical capacity resulting from training or physical exercise was impossible.

The first aspect to be analysed in this study was the existence of differences between the distances obtained in the first and second trials. In all of the test participants, a statistically significant difference was observed in the obtained distances. Only three out of the thirty participants in the study obtained a worse result in the second trial when compared to the distance obtained in the first trial. The testing conditions and the instructions given to the participants were identical in both cases. It can therefore be concluded that a learning effect occurred in the six-minute walk test. It is important to note that the study was conducted with healthy young persons in whom no respiratory distress and mobility limitations have been observed. Also, as has already been mentioned, an increase in the participants' physical capacity was impossible, and therefore, the reasons for an increase in the length of the second distance must be sought elsewhere.

These reasons may include the fact that while walking for the first time, the participants become accustomed to the surrounding environment and its conditions after a certain period of time. In addition, they are initially not sure whether they will be able to successfully complete the test at all. In the first trial, the participants can also check whether they can quicken their pace at a given moment and if this will constitute a problem for them, and can also come to a conclusion that they started the test at too low a speed because they do not feel an increase in exhaustion. The instruction given prior to the test, "Walk the longest distance possible", instead of "Walk as fast as possible", is not always fully understood, especially by healthy young people. However, perhaps in patients with respiratory and/or cardiovascular diseases, this would have a smaller impact due to their low tolerance for exercise. In summary, during the first trial, the participants learn how to optimally distribute their strength in order to walk as long a distance as possible. An adequate rest period between the successive trials was also important, and in this case the study group only rested for approximately 15 minutes between the trials. Perhaps this was too short a period, which did not allow them to fully recover. Although the rest period was small, the achieved improvement in the walk distance was statistically significant, and perhaps after a longer rest, the difference in the walk distance could be even greater.

The guidelines of the American Thoracic Society (ATS) of March 2002 specify the procedure for conducting the six-minute walk test[1]. They include the instruction that only one trial of the 6MWT should be conducted, and it can be argued that the differences in the distances are not big, and that the learning effect will weaken and disappear within a few weeks. Until recently, there were no recommendations concerning specific aspects of conducting the six-minute walk test; however, in the period from 1995 to 2004, several guidelines were published by scientific societies concerning various aspects of conducting the test[1,11,19]. Unfortunately, these guidelines differed on many important issues including, among other things: the speed of walking, the monitoring of saturation, the use of a preliminary trial, the period of rest between the trials, or the use of appropriate encouragement (motivating the participants to walk faster). As a result, it is impossible to compare two tests conducted in two different clinical research sites, and similar reservations have been raised concerning the results of tests conducted by different researchers within one unit.

The guidelines of the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) of 1998[11] mentioned, for example, the need to conduct a preliminary trial prior to the actual test, whose results were supposed to be reliable. It was suggested that the period between the tests should be at least one hour. On the other hand, the guidelines of the American Thoracic Society (ATS) of 2002 mention conducting the second trial as optional[1]. Immediately after the publication of the guidelines of the ATS in 2002, there were several publications (i.e. letters to the editor), in which the authors expressed their astonishment at the lack of a clear standard requiring the performance of two trials[20,21]. These publications referred to many different studies that had demonstrated that the distances achieved in the second, and sometimes even the third or fourth trial (test), were significantly better than in the first trial. Brooks and Solway[20] wrote: "*We were surprised to note that the guidelines did not recommend practice walks, but rather stated that a practice test is "not needed in most clinical settings"*; and later: *"In fact, studies of repeated testing have shown that performance on the 6-minute walk test is unstable on the ini-*

tial two walks and only becomes consistent on the third, suggesting the necessity of two practice walks for individuals with cardiorespiratory disease". They cited articles by Solway et al.[9] from 2001, and three publications by Guyatt et al. in 1984 and 1985[22-24]. But despite the possibility of a public response to this letter, the board who had prepared the standards for conducting the six-minute walk test "*did not express such an interest*".

A similar situation occurred in the case of another letter, which was written to the publisher of the guidelines by Gibbons in 2003[21]. In his letter, Gibbons mentions that despite the fact that the guidelines mention a search of the MEDLINE database for the period from 1970 to 2001, they did not include the articles that suggested the need for conducting a preliminary trial prior to the six-minute walk test. He also refers to his study from 2001 by Gibbons et al.[25], where the improvement in the second trial of a population of patients with COPD was 21%. In his opinion, this could change the interpretation of the test results in a significant way, but the guidelines of the ATS of 2002[1] only mention a difference of just 5%.

Subsequent guidelines of the AACVPR in 2004[19] recommended the use of the guidelines of the ATS from 2002; however, they also indicated the possibility of systematic errors in the six-minute walk test resulting from preliminary trials and from encouragement given by the rehabilitation personnel. The 2004 guidelines of the AACVPR[19] state that the Guidelines Board of the AACVPR supports the guidelines created by the ATS concerning the six-minute walk test, but they also recommend, for example, that the measurement of saturation during the test should not be optional, but should be obligatory. In addition, security concerns may require a member of the personnel to walk behind the patient during the test. Unfortunately, the 2011 guidelines of the AACVPR[3] simply reprint the 2002 guidelines of the ATS in Appendix B, and do not raise the issue of the learning effect and the performance of the second walk trial at all.

Given the results obtained in this study, which evidence the existence of a learning effect in the six-minute walk test, a return to the earlier guidelines (e.g., the guidelines of the AACVPR of 1998[11]) should be considered. By conducting a preliminary trial, the participant as the possibility of improving their result in the actual six-minute walk test, which is supported by the fact that 90% of the test participants improved their result. In addition, although small, the differences in the obtained distances turned out to be statistically significant, which further supports the necessity to perform a preliminary trial. In a population of patients with cardiovascular or respiratory dysfunctions, a higher level of fear of new tasks and challenges may be observed, and the fear of complications, unpleasant side effects, or failure can have a reflection on the obtained distance. After the first trial, when participants have subjectively evaluated their mood and their physical abilities, they may be more mentally prepared to perform the actual test. It should be mentioned that the occurrence of statistically significant differences in the obtained distances may evidence a reduced reliability in studies where only one trial is performed; however, Jenkins and Cecins[26] conducted a study that confirms the above theses. Their study involved 349 persons with respiratory diseases. The aim of their study was to determine whether conducting a preliminary 6MWT was necessary, and they found that 80% of the test participants obtained a better result in the second trial of the six-minute walk test[26].

In another study, Casey et al.[27]conducted three preliminary trials and one actual test with 55 persons with Down's Syndrome. The mean distances obtained by the patients were: Trial 1 – 395 m, Trial 2 – 428 m, Trial 3 – 433 m, and Trial 4 – 436 m. The greatest difference in the mean distance in the six-minute walk test was observed between Trials 1 and 2; therefore, the need to conduct as many as three preliminary trials in this study group may be questioned. Perhaps, considering the existence of the learning effect, it should also be necessary to conduct the same study in groups differing in age, sex, and health status.

Another aspect which is worth considering is the instruction given to the test participants, and its impact on the length of the obtained distance. In the conducted study, the participants were twice instructed to "walk as long a distance as possible during the six minutes of the test". An identical study should be conducted using the different instruction, "Walk as fast as possible during the six minutes of the test", and the results compared. In all studies where the participants/patients individually select the level of strain according to their capabilities (in this case, the speed of walking), the patient's motivation and attitude towards the test are of great importance. Therefore, in order to obtain the most objective results possible, no instructions that could increase the participants' motivation were used in the study, except for an identical instruction to all participants. It should also be mentioned that none of the respondents knew what the aim of the experiments was, and this helped them to avoid consciously obtaining a better result in the second trial in order to confirm the assumptions of the study.

It seems that, when interpreting the results of the six-minute walk test, the issues of the initial preliminary trial and the learning effect are important, as otherwise the improvement in the walk distance could be incorrectly interpreted. Therefore, in order to evaluate effects of a given therapeutic procedure (e.g., rehabilitation or training programme) using the six-minute walk test, it seems necessary to conduct two walk tests (the preliminary test and the actual test) prior to the procedure; and one more test after it, to allow for a comparison of the results of the second and third trials. This would allow for the elimination of the learning effect, and the correct interpretation of the possible improvement in the distance as an effect of the treatment. a possible improvement would then prove to be the result of the applied procedure, and not the result of a learning effect.

Unfortunately, the choice of procedures for conducting the six-minute walk test is currently an individual

matter. We can only hope that there will be a new update of the guidelines in the near future that will solve the problems in the testing methodology. The results of this study support the opinions of all those who suggest that conducting one preliminary trial prior to the test is a necessary routine.

Interestingly, the results of the comparison of the feelings of exhaustion after the first and second trials may indicate that men and women perform physical exercise in different ways. In the group of women, a statistically significant difference in the feeling of exhaustion was found between the first and the second trials; where the women reported greater exhaustion after the second trial. In the men, no such significance was observed; however, they reported greater levels of exhaustion after the first trial. After the second test, there was no difference in these results according to sex. The increase in the distance walked in the group of women in the second trial may result from their adaptation to the testing procedure and a stronger commitment in the second trial; whereas in men it may result only from their getting accustomed to the test, or to a learning effect.

In the present study, after the test the participants were asked "Would you be able to walk faster?", in addition to the question "Would you be able to walk farther?" (in accordance with the guidelines of the ATS). The results indicate that these questions were not synonymous and only the question about the participant's ability to go farther ("Would you be able to walk farther?") provided them with an opportunity to improve their result, as even though the test participants stated that they were not able to walk faster after the first trial, at the same time they suggested that they could go farther (and indeed, they obtained a significantly better distance in the second trial). Therefore, in the group of young people, despite feeling that they had walked the maximum distance they could (which was reported after the first trial as their inability to walk faster) the walk distance improved, which again confirms that a learning effect in the 6-minute walk test occurred in this group.

CONCLUSIONS

The study allows us to formulate the following conclusions:

1. A learning effect of the six-minute walk test occurs in young persons.
2. There were significant differences in the distances walked by the test participants in two trials of the six--minute walk test. The majority of the participants (90%) improved their result in the second trial of the 6MWT.
3. To avoid an incorrect interpretation of the results, it is necessary to conduct two trials (with one preliminary trial prior to the actual test) as a routine procedure. This will ensure the elimination of the learning effect, and will support the correct interpretation of the possible improvements in the distance as an effect of therapeutic procedures.
4. In healthy persons, it is more reasonable to ask the person whether they are able to continue the test after the first trial (Would you be able to walk farther?) rather than whether they are would be to increase their speed (Would you be able to walk faster?).
5. When analysing the differences according to sex, it will be necessary to increase the number of study participants, particularly in the group of men.

Conflict of interest: none declare

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